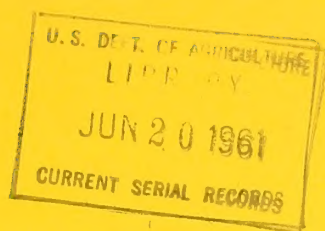


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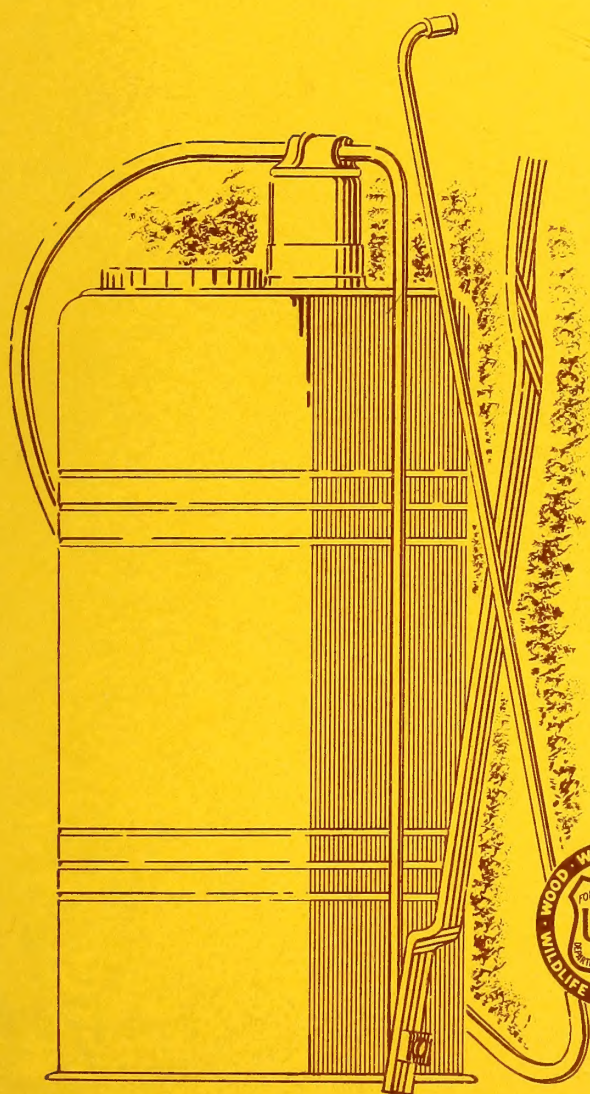


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CHEMICAL CONTROL of BRUSH *in Ponderosa Pine Forests* *of Central Oregon*

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March 1961)1

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INTRODUCTION

The many acres of forest land that are occupied by brush in central Oregon represent a large-scale waste of timber-growing capacity and a major economic loss to the area. Although large brushfields devoid of tree growth present the most spectacular examples of loss, less obvious but equally important brush problems are common in established timber stands. Brush frequently overtops and suppresses young seedlings for long periods of time in small natural forest openings and competes with trees of all sizes for soil moisture.

The three most common brush species in central Oregon are pine manzanita (Arctostaphylos parryana var. pinetorum), snowbrush ceanothus (Ceanothus velutinus), and golden chinkapin (Castanopsis chrysophylla). Manzanita, the most light demanding of the three, is usually the major species in large brushfields. It also occurs frequently in small openings of irregularly stocked forests or as an understory beneath sparsely stocked ponderosa pine (Pinus ponderosa) stands (fig. 1). Manzanita offers especially severe competition^{1/} to young pine seedlings (fig. 2) and may delay regeneration of small openings or sparsely stocked stands for many years.



Figure 1. — Understocked old-growth ponderosa pine with manzanita understory.

^{1/} Dahms, Walter G. The effect of manzanita and snowbrush competition on ponderosa pine reproduction. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 65, 3 pp. 1950. (Processed.)



Figure 2. — Suppressed ponderosa pine growing very slowly beneath manzanita. 2, 4, 5 - T can be used to release such seedlings from overtopping manzanita without serious damage to trees.

Snowbrush, intermediate in shade tolerance between manzanita and chinkapin, is often associated with manzanita in open situations but is also able to grow as an understory shrub beneath well-stocked pine stands. Consequently it probably competes with the pines in an important way for soil moisture. In managed stands, it may be necessary to use direct brush control if trees are to be grown at the low stand densities required for fast individual tree growth.

Chinkapin is usually found in the more moist parts of the ponderosa pine zone, especially on north slopes or at higher elevations. A high tolerance for shade and an ability to grow in an understory position indicate chinkapin probably is an aggressive competitor for soil moisture.

Manzanita does not sprout following death of aerial parts, but snowbrush and chinkapin do. Snowbrush sprouts have overtaken and crowded out trees planted following a burn. Chinkapin sprouts also grow rapidly and probably have the potential to overtake and crowd out planted trees.

Central Oregon forest managers need brush control to accomplish the following objectives:

1. Prepare brushfields for planting or seeding.
2. Release existing trees from overtopping brush.
3. Eliminate understory brush where it competes with trees for soil moisture.

Purpose of this paper is to briefly summarize results of earlier (1953 and 1954) chemical brush control studies which have already been reported^{2/} and to more completely describe findings from more recent (1955 and 1956) experiments.

EARLY STUDIES

Chemical brush control methods were shown to be practical on central Oregon forest lands when aerial spraying first proved to be successful in 1954. Manzanita was completely killed and aerial parts of snowbrush deadened. Furthermore, a few undamaged ponderosa pine trees standing in 2, 4-D-killed manzanita at the edge of aerial spray plots demonstrated that selective manzanita control (control without serious damage to intermingled pine trees) was possible.

Rates of 2, 4-D^{3/} tried for the initial aerial application were 1, 2, and 3 pounds^{4/} per acre. The 1-pound rate proved to be completely effective on manzanita. Dead brush in drift areas beyond plot boundaries suggested a lesser rate probably would be effective. Aerial parts of snowbrush were almost all killed by the 2-pound rate, but 1 pound killed only the tips of most twigs and parts of most leaves.

Spray volumes tried in the 1954 aerial spray experiment included 3, 5, and 10 gallons per acre with a 2-pound-per-acre rate of 2, 4-D, and 10 gallons with the 1- and 3-pound rate. All treatments were completely effective on manzanita and no differences in effectiveness on snowbrush associated with spray volume were evident. The evidence suggests that a 3-gallon spray volume would also be successful on manzanita with a 1-pound rate but provides no conclusive proof.

Small-scale tests on chinkapin in 1953 and 1954 showed that aerial parts could be killed with either 2, 4-D or 2, 4, 5-T applied as a foliage spray, but sprouting always followed. Rates tried were as low as 2 pounds per acre but no minimum effective rate was established. Because spray was applied with a hand sprayer, no minimum effective spray volume for aerial application was obtained.

^{2/} Dahms, Walter G. Chemical brush control on central Oregon ponderosa pine lands. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 109, 5 pp. 1955. (Processed.)

^{3/} Common and chemical names of herbicides mentioned in this report are listed on the inside back cover.

^{4/} Acid equivalent for the phenoxy herbicides discussed in this report: 2, 4-D, 2, 4, 5-T, 2-(2, 4-DP), and silvex.

RECENT STUDIES

A new series of experiments was installed in 1955 and 1956, with the following objectives:

1. To determine if manzanita, snowbrush, or chinkapin could be controlled by broadcast spray applications without injury to intermingled ponderosa pine trees (selective control) and to define suitable treatments.
2. To determine if sprouting of snowbrush and chinkapin could either be eliminated or greatly reduced by chemical treatment.

Studies to determine relative tolerance of ponderosa pine and manzanita to various herbicides were given special emphasis in 1955 as an essential step in attaining objective 1.

Methods

2, 4-D and 2, 4, 5-T were the herbicides tested most completely, but 2-(2, 4-DP), silvex, amitrole, and trichlorobenzoic acid were also tried. The phenoxy compounds (2, 4-D, 2, 4, 5-T, 2-(2, 4-DP), and silvex) were always used as the PGBE^{5/} esters.

The two carriers tested were water and oil-in-water emulsion. The emulsion carrier contained 1 gallon of summer oil^{6/} per acre.

Herbicides were applied to the brush and trees as a foliage spray with a hand sprayer. Trees were understory saplings growing in dense stands (fig. 3). In most cases, all vegetation within a 1/100-acre rectangular plot was sprayed with a volume of 100 gallons per acre. Each treatment was repeated on two plots at each date of application. A slightly different procedure was used on one snowbrush study because the plants were too far apart to cover an entire 1/100-acre plot. In this case, individual bushes were sprayed after the area occupied by each bush was measured and the amount of spray adjusted according to area occupied. Where individual plants were treated, spray volume was raised to 150 gallons per acre.

Percentage of brush cover dead was the criterion used to rate effectiveness of brush treatments. It was estimated by means of 100 systematically located points on each plot. A plumb bob was dropped at each of the 100 points,

^{5/} Propylene glycol butyl ether.

^{6/} A petroleum product of low toxicity to plants that readily goes into an oil-in-water emulsion.



Figure 3. — A dense understory of ponderosa pine saplings typical of trees used to determine tolerance of ponderosa pine to herbicides.

and at those locations where brush was encountered it was rated as dead or live. Before percentage of brush cover dead was adopted as the criterion to be used, percentage of plants dead on each plot was tried on manzanita plots. Results were nearly the same regardless of the criterion used.

The standard used to rate tolerance of ponderosa pine to herbicide treatments was percentage of terminal buds or leaders dead.

Growth rate of ponderosa pine before and after treatment and number of years of growth killed were measured on 19 trees growing on two aerial spray plots that had received approximately 1 pound per acre of 2,4-D in an emulsion carrier. These plots were treated in 1954.

Examinations were generally made in the summer of the year following treatment. Where treatments had been applied in late summer or early fall, examinations were delayed until the second summer after treatment. However, amount of sprout growth that would eventually develop could not always be gaged at the end of the 1- to 2-year period after treatment.

The various treatments applied to manzanita, chinkapin, snowbrush, and ponderosa pine are shown in tables 1 to 4.

Table 1.--Herbicide treatments applied as foliage sprays to
pine manzanita, by date of application, 1955

Chemical and carrier ^{1/}	Date of application ^{2/}			
	May 6	May 27	July 5	Sept. 22
----- Pounds -----				
2,4-D:				
Water	0.50	0.50	0.50	0.25
do	.75	.75	.75	.50
do	1.00	1.00	1.00	1.00
Emulsion	.50	.50	.50	.25
do	.75	.75	.75	.50
do	1.00	1.00	1.00	1.00
2,4,5-T:				
Water	.50	.50	.50	.25
do	.75	.75	.75	.50
do	1.00	1.00	1.00	1.00
Emulsion	.50	.50	.50	.25
do	.75	.75	.75	.50
do	1.00	1.00	1.00	1.00

^{1/} Propylene glycol butyl ether esters of both chemicals were used; rate of application is in pounds (acid equivalent) per acre. The emulsion carrier contained 1 gallon of summer oil per acre.

^{2/} Stage of plant development by date:

May 6. Few blossoms starting on manzanita; no other visible sign of growth activity; last of snow had melted only a few days before.

May 27. Manzanita blossoming nearly over; ponderosa pine buds beginning to elongate; bitterbrush starting to leaf out; no visible snowbrush activity.

July 5. Manzanita blossoming complete and new fruits formed; twig growth well under way on most brush species; ponderosa pine height growth continuing; snowbrush still blossoming.

Sept. 22. No visible signs of growth on either trees or shrubs; first light fall rains had fallen but the soil was still dry.

Table 2.--Herbicide treatments applied as foliage sprays to golden chinkapin, by date of application, 1955 and 1956

Chemical and carrier ^{1/}	Date of application ^{2/}			
	1955			1956
	June 16	July 15	Sept. 29	(July 13)
	Pounds			
2,4-D:				
Water	1.5	--	1.5	1.0
do	--	--	--	.5
Emulsion	1.5	--	1.5	1.0
do	--	--	--	.5
2,4,5-T:				
Water	1.5	--	1.5	1.0
do	--	--	--	.5
Emulsion	1.5	--	1.5	1.0
do	--	--	--	.5
2-(2,4-DP):				
Water	1.5	--	1.5	1.0
do	--	--	--	.5
Emulsion	1.5	--	1.5	1.0
do	--	--	--	.5
Silvex:				
Water	1.5	--	1.5	1.0
do	--	--	--	.5
Emulsion	1.5	--	1.5	1.0
do	--	--	--	.5
2,3,6-TBA (suspended acid):				
Water	--	3.0	--	--
do	--	15.0	--	--
2,3,6-TBA (sodium salt):				
Water	--	3.0	--	--
do	--	15.0	--	--
Amitrole:				
Water	--	4.0	--	--

^{1/} Propylene glycol butyl ether esters of the phenoxy herbicides 2,4-D, 2,4,5-T, 2-(2,4-DP), and silvex were used. Rate of application of all chemicals is in pounds per acre (acid equivalent for the phenoxy herbicides). The emulsion carrier contained 1 gallon of summer oil per acre.

^{2/} Stage of plant development by date:

June 16, 1955. No active growth evident.

July 15, 1955. New growth about half complete on chinkapin and proceeding rapidly; snowbrush in full blossom and growing rapidly.

Sept. 29, 1955. No visible indications of active growth.

July 13, 1956. New chinkapin twig growth about half complete; flower stalks approaching full length but flowers not yet open.

Table 3.--Herbicide treatments applied as foliage sprays to
snowbrush ceanothus, by date of application, 1955
and 1956

Chemical and carrier ^{1/}	Date of application ^{2/}			
	1955			
	June 14	Aug. 2	Sept. 28	1956 (July 18)
----- Pounds -----				
2,4-D:				
Water	1.5	--	1.5	--
do	1.0	--	1.0	--
Emulsion	1.5	--	1.5	--
do	1.0	--	1.0	--
2,4,5-T:				
Water	1.5	--	1.5	--
do	1.0	--	1.0	--
Emulsion	1.5	1.0	1.5	--
do	1.0	.5	1.0	--
2-(2,4-DP):				
Emulsion	--	--	--	1.5

^{1/}Propylene glycol butyl ether esters of all chemicals were used; rate of application is in pounds (acid equivalent) per acre. The emulsion carrier contained 1 gallon of summer oil per acre.

^{2/}Stage of plant development, by date:

June 14, 1955. First snowbrush twig growth starting.

August 2, 1955. Active growth nearly complete.

Sept. 28, 1955. All visible signs of active growth gone.

July 18, 1956. Twig growth active.

Table 4.--Herbicide treatments applied as foliage sprays to ponderosa pine, by date of application, 1955 and 1956

Chemical and carrier ^{1/}	Date of application ^{2/}					
	1955					1956
	May 5	May 26	July 1	Aug. 2	Sept. 29	(July 18)
	Pounds					
2,4-D:						
Water	0.75	0.75	0.75	--	0.25	--
do	1.00	1.00	1.00	--	.50	--
do	1.50	1.50	1.50	--	1.00	--
Emulsion	.75	.75	.75	0.50	.25	--
do	1.00	1.00	1.00	--	.50	--
do	1.50	1.50	1.50	--	1.00	--
2,4,5-T:						
Water	.75	.75	.75	--	.50	--
do	1.00	1.00	1.00	--	1.00	--
do	1.50	1.50	1.50	--	1.50	--
Emulsion	.75	.75	.75	.50	.50	--
do	1.00	1.00	1.00	1.00	1.00	--
do	1.50	1.50	1.50	--	1.50	--
Silvex:						
Water	--	--	1.00	--	1.50	--
do	--	--	1.50	--	--	--
Emulsion	--	--	--	--	1.50	--
2-(2,4-DP):						
Water	--	--	1.00	--	1.50	--
do	--	--	1.50	--	--	--
Emulsion	--	--	--	--	1.50	0.75
do	--	--	--	--	--	1.50

^{1/}Propylene glycol butyl ether esters of all chemicals were used; rate of application is in pounds (acid equivalent) per acre. The emulsion carrier contained 1 gallon of summer oil per acre.

^{2/}Stage of plant development, by date:

May 5, 1955. Few blossoms starting on manzanita; no other visible sign of growth activity; last of snow melted only a few days before.

May 26, 1955. Manzanita blossoming nearly over; ponderosa pine buds beginning to elongate; bitterbrush starting to leaf out; no visible snowbrush activity.

July 1, 1955. Manzanita blossoming complete and new fruits formed; twig growth very active on most brush species; ponderosa pine height growth continuing; snowbrush still blossoming.

Aug. 2, 1955. Height growth of ponderosa pine complete.

Sept. 26, 1955. No visible signs of growth on either trees or shrubs; first light fall rains had fallen but the soil was still dry.

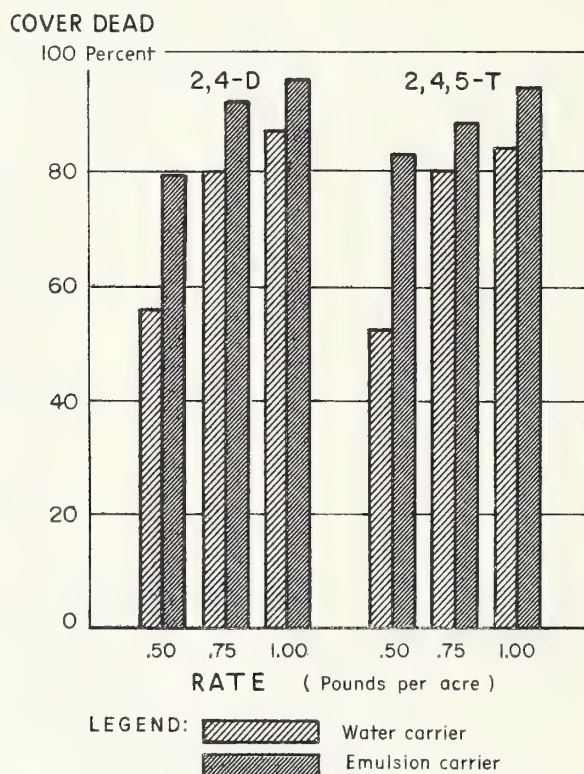
July 18, 1956. Slow height growth continuing on ponderosa pine; manzanita and snowbrush still actively growing.

Results

Pine Manzanita

Foliage sprays of 2, 4-D and 2, 4, 5-T were found to be highly and equally effective on manzanita when applied during the period from early May to early July (fig. 4). Rates of application for both chemicals as low as 0.5 pound per acre in an emulsion carrier or 0.75 pound in a water carrier resulted in an average kill close to 80 percent. Thus, approximately two-thirds as much chemical is required with an emulsion carrier as with a water carrier to achieve a specified degree of control.

Figure 4 — Average percentage of manzanita cover killed by 2, 4-D and 4, 5-T applied during the growing season (combined results for May 6, May 27, and July 5, 1955—basis, 72 plots). The emulsion carrier contained 1 gallon of summer oil per acre.



Susceptibility of manzanita to both 2, 4-D and 2, 4, 5-T rose gradually from early May and reached a high point in early July. By late September, effectiveness of both chemicals had fallen off greatly (fig. 5). Results from a 1953 experiment^{7/} at Pringle Falls Experimental Forest indicate that effectiveness of both

^{7/} Dahms, Walter G. Chemical brush control on central Oregon ponderosa pine lands. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 109, 5 pp. 1955. (Processed.)

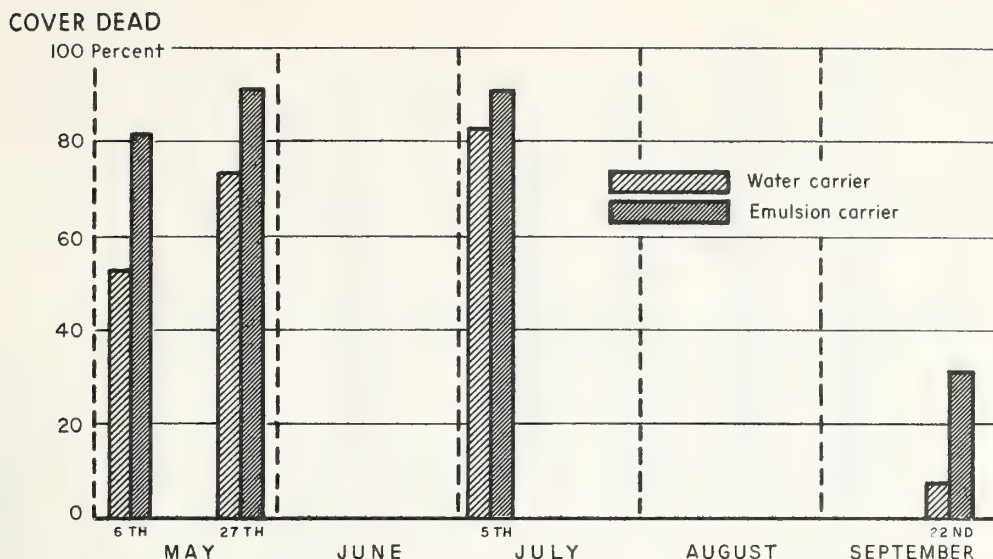


Figure 5. — Percentage of manzanita cover killed by 2, 4 - D and 2, 4, 5 - T applied at four different dates (basis: 64 plots). Results from 0.5- and 1-pound-per-acre rates were averaged for each date. The emulsion carrier contained 1 gallon of summer oil per acre.

herbicides had already begun to fall off by July 31. Effectiveness of 2, 4, 5-T fell off even more rapidly than did that of 2, 4-D as the season advanced. The late September application of 2, 4, 5-T at the 1-pound rate in emulsion carrier killed only 33 percent of the manzanita cover, compared with 66 percent killed by 2, 4-D.

Differences in percentage of manzanita cover killed between the two carriers and between the four dates of application were statistically significant at the 1-percent probability level. Differences between chemicals were significant only for the late September application, at the 1-percent level.

Golden Chinkapin

Tests on chinkapin showed that 2, 4, 5-T was the most effective chemical, that an emulsion carrier was definitely superior to a water carrier, and that mid-June treatments produced a better kill of aerial parts than late September applications (fig. 6). The mid-July 1956 test further showed that the 0.5-pound-per-acre rate of 2, 4, 5-T in an emulsion carrier produced a complete top kill. Amitrole and trichlorobenzoic acid were not effective.

Differences between effectiveness of 2, 4, 5-T, 2, 4-D, silvex, and 2-(2, 4-DP) at the mid-June application were significant at the 1-percent level. Difference in effectiveness between emulsion and water carriers was significant at the 5-percent level.

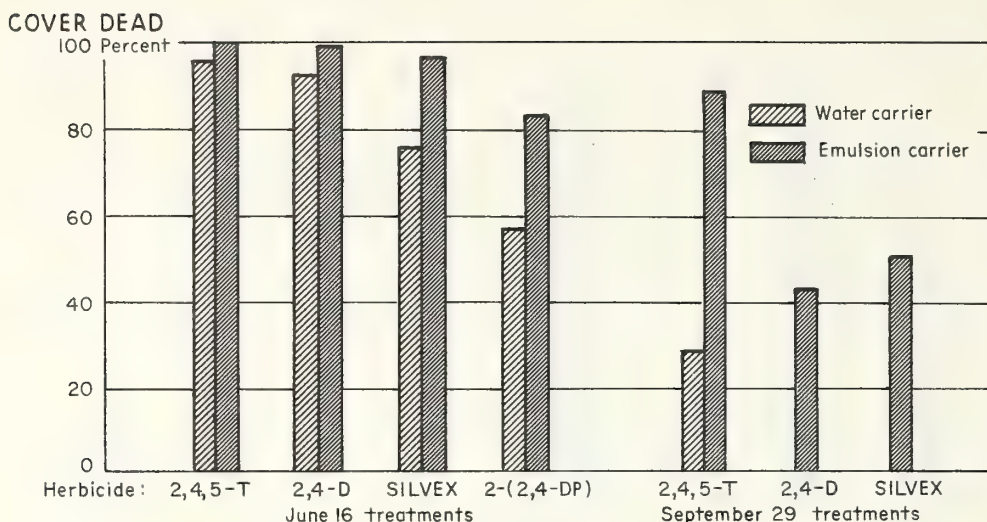


Figure 6. — Average percentage of chinkapin cover killed by four herbicides applied June 16 and September 29 at the rate of 1.5 pounds per acre (basis: 24 plots). The emulsion carrier contained 1 gallon of summer oil per acre. The 2, 4-D and silvex in water carriers and the 2- (2, 4-DP) in either a water or an emulsion carrier did very little damage in the September 29 treatments and consequently are not represented on the chart.

Sprouts have developed on chinkapin plants treated at any time from mid-June to late September; earlier treatments were not tried. Sprouts on chinkapin plots treated in 1953 formed a solid cover and averaged about 18 inches tall by the fall of 1960. Fall treatment of chinkapin with 2, 4, 5-T in an emulsion carrier may delay sprouting. No sprouts appeared for 2 years following treatment in the fall of 1955, but numerous small sprouts had appeared by the end of 1960.

Effect of herbicides on central Oregon chinkapin is quite different from that on chinkapin found in southwestern Oregon. Gratkowski^{8/} found that southwestern Oregon chinkapin was resistant to all herbicide treatments tested. The reason for this difference is not known.

^{8/} Gratkowski, H. Effects of herbicides on some important brush species in southwestern Oregon. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Paper 31, 33 pp., illus. 1959. (Processed.)

Snowbrush Ceanothus

Information on effectiveness of herbicides applied to snowbrush is less complete than for the other two brush species because a severe freeze in November 1955 destroyed an experiment before results could be fully evaluated. Available facts come from a 1954 aerial spraying experiment, from intermingled snowbrush plants growing on the manzanita plots, and from incomplete observations on the snowbrush experiment prior to the freeze.

2, 4, 5-T was the most effective chemical tried on snowbrush. 2, 4-D and 2-(2, 4-DP) were also effective but greater amounts were required. Rates of 1 pound per acre of 2, 4, 5-T and 1.5 pounds of 2, 4-D are adequate in an emulsion carrier, but 1.5 pounds of 2, 4, 5-T are required in a water carrier. The effective rate for 2, 4-D in water was not reached. One and one-half pounds of 2-(2, 4-DP) in an emulsion carrier may also be effective. These rates are for foliage sprays applied during the active growing season.

Snowbrush has sprouted vigorously following all chemical treatments tried so far. Rate of sprout growth is illustrated by data from the 1954 aerial spray plots. Before the area was sprayed, snowbrush covered 16.5 percent of the ground. By the fall of 1956, snowbrush sprouts covered 6.3 percent of the area and plants not killed back by spraying covered 1.0 percent. Thus two and a half growing seasons after spraying, snowbrush covered nearly half of the area it occupied before spraying.

Ponderosa Pine

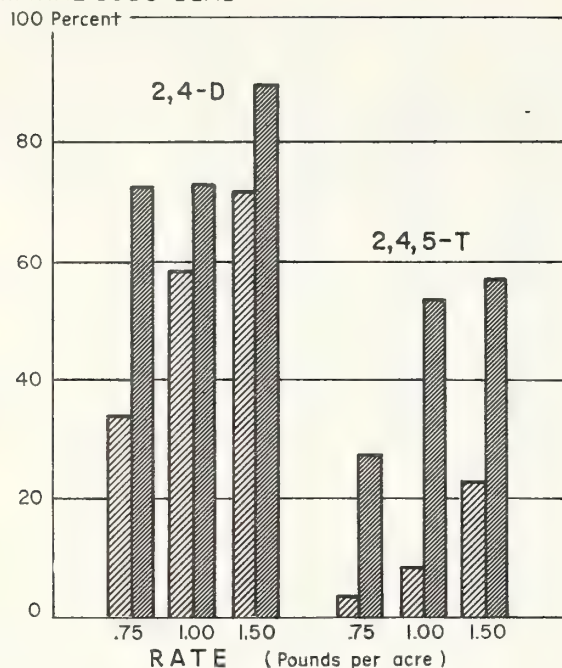
Ponderosa pine can tolerate about twice as much 2, 4, 5-T as 2, 4-D and about twice as much of either chemical in a water carrier as in an emulsion carrier. These relationships are illustrated by the similar amount of damage caused by 0.75 pound of 2, 4-D in water, 0.75 pound of 2, 4, 5-T in an emulsion carrier, and 1.5 pounds of 2, 4, 5-T in water (fig. 7).

Tolerance of ponderosa pine to 2, 4-D and 2, 4, 5-T varies with the season. Of dates tested, trees were most damaged by early July treatments and least damaged by late September treatments (fig. 8). Terminal buds were killed on only a few trees following late September application of 2, 4-D in an emulsion carrier at the rate of 1 pound per acre. No terminal leaders were killed by other treatments.

Relative tolerance of ponderosa pine to four common herbicides is shown graphically in figure 9. Ponderosa pine is most susceptible to 2, 4-D and most tolerant of 2-(2, 4-DP). Tolerance to 2, 4, 5-T and silvex is intermediate.

Differences in percentage of terminal buds killed between water and emulsion carriers, between different treatment dates, and between 2, 4-D and 2, 4, 5-T were significant at the 1-percent probability level. Differences in number of terminal buds killed by 2, 4, 5-T and silvex and by silvex and 2-(2, 4-DP) were significant at the 5-percent level.

TERMINAL BUDS DEAD



LEGEND:  Water carrier  Emulsion carrier

Figure 7. — Average percentage of ponderosa pine terminal buds killed by 2, 4 - D and 2, 4, 5 - T applied during the growing season (combined results for May 5, May 26, and July 1, 1955 — basis, 72 plots). The emulsion carrier contained 1 gallon of summer oil per acre.

TERMINAL BUDS DEAD

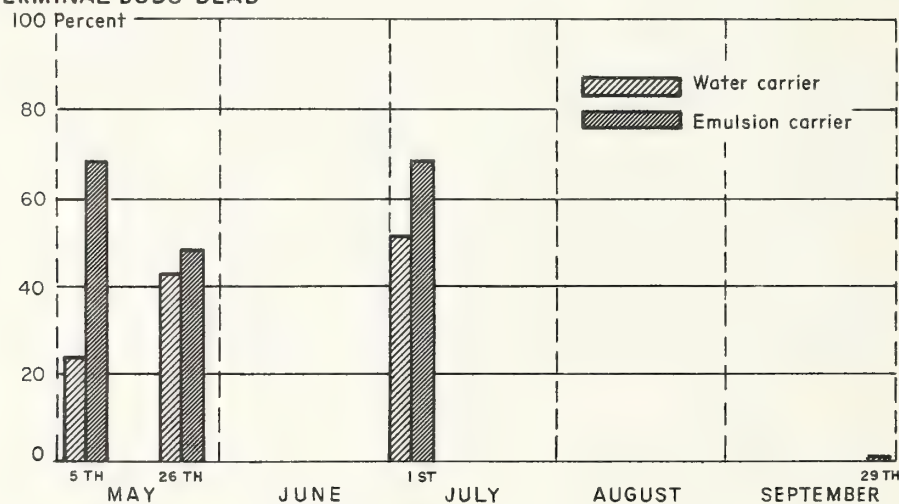
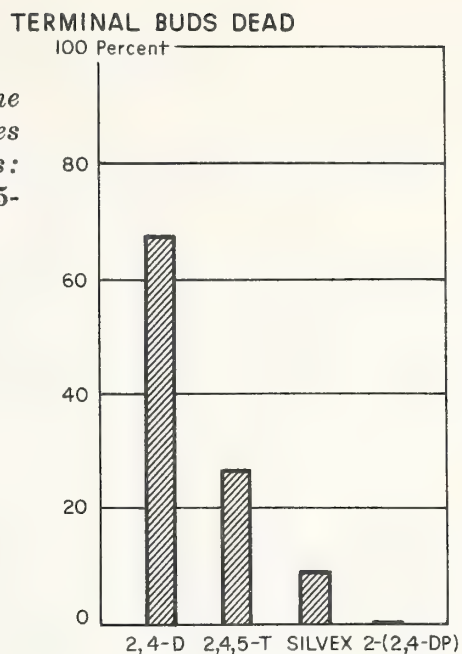


Figure 8. — Combined average percentage of ponderosa pine terminal buds killed by 2, 4 - D and 2, 4, 5 - T applied at the rate of 1 pound per acre at four different dates (basis: 32 plots). The emulsion carrier contained 1 gallon of summer oil per acre. September 29 treatments with the water carrier killed no terminal buds.

Figure 9. — Percentage of ponderosa pine terminal buds killed by four herbicides applied July 1 in a water carrier (basis: 16 plots). Results from 1- and 1.5-pound-per-acre rates were averaged.



Arend^{9/} reported a sharp drop in susceptibility of Lake States conifers to 2,4-D and 2,4,5-T as soon as height growth ceased. Ponderosa pine trees in central Oregon apparently develop tolerance more gradually. For example, 2,4,5-T at the rate of 1 pound per acre in an emulsion carrier killed the following percentages of terminal buds at each of five dates:

<u>Date of application</u>	<u>Terminal buds killed</u> (Percent)
May 5	56
May 26	37
June 30	75
August 2	29
September 26	0

There is some evidence that effective control of brush without injury to intermingled conifers may also depend on the particular formulation of 2,4-D or 2,4,5-T used. Krygier,^{10/} for example, found that the butoxy ethanol esters of

^{9/} Arend, John L. Tolerance of conifers to foliage sprays of 2,4-D and 2,4,5-T in lower Michigan. U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Note 437, 2 pp. 1955. (Processed.)

^{10/} Krygier, James T. Effect of herbicides on salmonberry and on Sitka spruce and western hemlock seedlings. 1960. (In preparation for publication.)

2, 4, 5-T damaged spruce and hemlock seedlings more than the propylene glycol butyl ether esters. Because the butoxy ethanol esters were not more effective on salmonberry, there was a loss in selectivity.

Observations on 19 ponderosa pine trees aerially sprayed in 1954 demonstrate that this species has the ability to recover rapidly following severe temporary damage from 2, 4-D sprays. In this case, 2, 4-D had been applied in an emulsion carrier at the rate of 1 pound per acre during early July when ponderosa pine is most susceptible to herbicides. Terminal leaders were killed by the spray on 10 of the 19 trees and some damage was done to at least one side of the crown on 15 trees. Leader kill-back on those trees that suffered this type of damage ranged from 1 to 5 years' growth and averaged 2 years'. Length of main stem killed back ranged from 0.5 to 1.8 feet and averaged 0.79 foot.

Growth was accelerated rather than reduced following 2, 4-D injury. Height growth of all 19 trees averaged 0.47 foot annually during the 2 years preceding treatment and 0.52 foot yearly during the 2 years following treatment. Similarly, diameter growth of 11 trees (those large enough to be bored) averaged 0.18 inch per year during the 2 years before spraying and 0.24 inch per year during the 2 years after spraying.

Increased growth seems attributable to increased soil moisture and possibly to increased soil nutrients made available by elimination of brush competition. Tarrant^{11/} has shown that live brush uses up available soil moisture during the early part of the growing season.

APPLICATION OF RESULTS

Pine manzanita can be effectively controlled with either 2, 4-D or 2, 4, 5-T at the rate of 0.5 to 0.75 pound per acre in an emulsion carrier or 0.75 to 1 pound in a water carrier. Where manzanita brushfields do not contain intermingled ponderosa pines that need to be saved, 2, 4-D in an emulsion carrier is the cheapest effective treatment. Where intermingled pine trees are present and should be saved, 2, 4, 5-T in water is the safest treatment. However, 2, 4, 5-T in an emulsion carrier at a rate of 0.5 pound per acre will cause only a small amount of temporary damage to ponderosa pine trees and is probably the best treatment.

Seasonal trends of susceptibility to herbicides are about the same for both manzanita and ponderosa pine. From late May until mid-July is therefore

^{11/}Tarrant, Robert F. Soil moisture conditions after chemically killing manzanita brush in central Oregon. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 156, 4 pp., illus. 1957. (Processed.)

recommended as the best time for treatment because the most effective brush control is obtained during this period.

For golden chinkapin and snowbrush ceanothus the recommendations that follow should be considered tentative. For both species, 2, 4, 5-T is the most effective chemical tested.

Aerial parts of chinkapin can be killed with 2, 4, 5-T at rates as low as 0.5 pound per acre in an emulsion carrier during the active growing season, a rate ponderosa pine trees can tolerate. Late-season applications at a rate of 1.5 pounds per acre in an emulsion carrier may delay sprouting. Furthermore, late-season treatment offers a greater margin of safety for intermingled trees. However, because of the limited experience with fall treatments on this species there is no certainty that a good kill of brush will always result.

Aerial parts of snowbrush can be killed with 2, 4, 5-T at the rate of 1 pound per acre in an emulsion carrier or 1.5 pounds per acre in a water carrier. The emulsion carrier is the most economical where there are no trees to protect. Vigorous sprouting has followed all treatments. Best prospects for treating snowbrush without serious damage to intermingled pine trees appear to be (1) use of 2, 4, 5-T with a water carrier or (2) use of 2-(2, 4-DP) with an emulsion carrier.

A total spray volume of 5 gallons per acre for aerial spraying with an emulsion carrier appears to be a safe amount for average central Oregon conditions. Further trials may show that considerably lesser spray volumes will be successful, especially on manzanita, a very sensitive species.

Common and Chemical Names of Herbicides Mentioned

2, 4-D	2, 4-dichlorophenoxyacetic acid
2, 4, 5-T	2, 4, 5-trichlorophenoxyacetic acid
2-(2, 4-DP)	2-(2, 4-dichlorophenoxy) propionic acid
Silvex	2-(2, 4, 5-trichlorophenoxy) propionic acid
Amitrole	3-amino-1, 2, 4-triazole
2, 3, 6-TBA	A mixture of 6 isomers of trichlorobenzoic acid

